9-5-00 A

JC921 U.S. PTO 08/31/00

Please type a plus sign (+) Inside this box ⊞

UTILITY PATENT APPLICATION TRANSMITTAL
(Only for new nonprovisional applications under 37 C.F.R. § 1 53(b))

Attorney Docket No.	15311-9822
First Inventor or Application Identifier	David Hartwell et al.
Title	CLOCK FORWARDING DATA RECOVERY
Express Mail Label No.	EL705602134

09/654459 PTO 08/31/00

APPLICATION ELEMENTS
See MPEP chapter 600 concerning utility application contents

ADDRESS TO: Assistant Commissioner for Patents
Box Patent Application
Washington, DC 20231

1. ☐ *Fee Transmittal Form (e.g., PTO/SB/17)
(Submit an original and a duplicate for fee processing)

2. ☒ Specification [Total Pages 10]
(preferred arrangement set forth below)
- Descriptive title of the Invention
- Cross References to Related Applications
- Statement Regarding Fed sponsored R & D
- Reference to Microfiche Appendix
- Background of the Invention
- Brief Summary of the Invention
- Brief Description of the Drawings *(if filed)*
- Detailed Description
- Claim(s)
- Abstract of the Disclosure

3. ☒ Drawing(s) [Total Sheets 1]

4. Oath or Declaration [Total Pages]
a. ☐ Newly executed (original copy)
b. ☐ Copy from a prior application (37 C.F R § 1.63(d))
(for continuation/divisional with Box 17 completed)
[Note Box 5 below]
DELETION OF INVENTOR(S)
I. ☐ Signed statement attached deleting inventor(s) named in the prior application, see 37 C F R §§ 1.63(d)(2) and 1 33(b).

5. ☐ Incorporation By Reference *(useable if Box 4b is checked)*
The entire disclosure of the prior application, from which a copy of the oath or declaration is supplied under Box 4b, is considered to be part of the disclosure of the accompanying application and is hereby incorporated by reference therein

6. ☐ Microfiche Computer Program *(Appendix)*

7. Nucleotide and/or Amino Acid Sequence Sequence Submission
((if applicable, all necessary)
a. ☐ Computer Readable Copy
b. ☐ Paper Copy (Identical to computer copy)
c. ☐ Statement verifying identity of above copies

ACCOMPANYING APPLICATION PARTS

8. ☐ Assignment Papers (cover sheet & document(s))
9. ☐ 37 C.F.R.§3.73(b) Statement (*when there is an assignee*) ☐ Power of Attorney
10. ☐ English Translation Document (*if applicable*)
11. ☐ Information Disclosure Statement (IDS)/PTO-1449 ☐ Copies of IDS Citations
12. ☐ Preliminary Amendment
13. ☒ Return Receipt Postcard (MPEP 503) (*Should be specifically itemized*)
14. ☐ *Small Entity Statement(s) (*(PTO/SB/09-12)*) ☐ Statement filed in prior application, Status still proper and desired
15. ☐ Certified Copy of Priority Document(s) (*if foreign priority is claimed*)
16 ☐ Other:

*NOTE FOR ITEMS 1 & 14: IN ORDER TO BE ENTITLED TO PAY SMALL ENTITY FEES, A SMALL ENTITY STATEMENT IS REQUIRED (37 C. F. R. §1.27), EXCEPT IF ONE FILED IN A PRIOR APPLICATION IS RELIED UPON (37 C. F. R § 1.28).

17. If a CONTINUING APPLICATION, *check appropriate box and supply the requisite information below and in a preliminary amendment*:
☐ Continuation ☐ Divisional ☐ Continuation-in-part (CIP) of prior application No.: /
Prior application Information: Examiner *Group/Art Unit:*

18. CORRESPONDENCE ADDRESS

☒ Customer Number or Bar Code Label (Insert Cus) 24267 PATENT TRADEMARK OFFICE (abel here) or ☐ Correspondence address below

Name	Michael R. Reinemann				
Address	Cesari and McKenna 88 Black Falcon Avenue				
City	Boston	State	MA	Zip Code	02210
Country	U. S. A.	Telephone	(617) 951-2500	Fax	(617) 951-3927

Name *(Print/Type)*	Michael R. Reinemann	Registration No. *(Attorney/Agent)*	38,280
Signature	Michael R. Reinemann	Date	August 31, 2000

PATENTS
15311-2289

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In Re The Application of: David Hartwell et al.	)	
Serial No.: Not Yet Assigned	)	Examiner: Not Yet Assigned
Filed: August 31, 2000	)	Art Unit: Not Yet Assigned
For: CLOCK FORWARDING DATA RECOVERY	)	

Cesari and McKenna, LLP
88 Black Falcon Avenue
Boston, MA 02210
August 31, 2000

EXPRESS-MAIL DEPOSIT

"Express Mail" Mailing-Label Number: EL705602134US

The following papers are being deposited with the United States Postal Service "Express Mail Post Office to Addressee" service pursuant to 37 C.F.R. §1.10:

_X_ Patent Application (9 pages including 5 claims)
_X_ Utility Patent Application Transmittal Letter
_X_ Informal Drawing (1 sheets)

UNITED STATES PATENT APPLICATION

of

David Hartwell

and

Darrell Donaldson

for a

CLOCK FORWARDING DATA RECOVERY

ENHANCED CLOCK FORWARDING DATA RECOVERY

INCORPORATION BY REFERENCE OF RELATED APPLICATIONS

This patent application is related to the following co-pending, commonly owned U.S. Patent Applications, all of which were filed on even date with the within application for United States Patent and are each hereby incorporated by reference in their entirety:

U.S. Patent Application Ser. No. (15311-2281) entitled ADAPTIVE DATA PREFETCH PREDICTION ALGORITHM;

U.S. Patent Application Ser. No. (15311-2282) entitled UNIQUE METHOD OF REDUCING LOSSES IN CIRCUITS USING V^2 PWM CONTROL;

U.S. Patent Application Ser. No. (15311-2283) entitled IO SPEED AND LENGTH PROGRAMMABLE WITH BUS POPULATION;

U.S. Patent Application Ser. No. (15311-2284) entitled PARTITION FORMATION USING MICROPROCESSORS IN A MULTIPROCESSOR COMPUTER SYSTEM;

U.S. Patent Application Ser. No. (15311-2285) entitled SYSTEM AND METHOD FOR USING FUNCTION NUMBERS TO INCREASE THE COUNT OF OUTSTANDING SPLIT TRANSACTIONS;

U.S. Patent Application Ser. No. (15311-2286) entitled SYSTEM AND METHOD FOR PROVIDING FORWARD PROGRESS AND AVOIDING STARVATION AND LIVELOCK IN A MULTIPROCESSOR COMPUTER SYSTEM;

U.S. Patent Application Ser. No. (15311-2287) entitled ONLINE ADD/REMOVAL OF SERVER MANAGEMENT INFRASTRUCTURE;

U.S. Patent Application Ser. No. (15311-2288) entitled AUTOMATED BACKPLANE CABLE CONNECTION IDENTIFICATION SYSTEM AND METHOD;

U.S. Patent Application Ser. No. (15311-2289) entitled AUTOMATED BACKPLANE CABLE CONNECTION IDENTIFICATION SYSTEM AND METHOD;

U.S. Patent Application Ser. No. (15311-2290) entitled CLOCK FORWARD INITIALIZATION AND RESET SIGNALING TECHNIQUE;

U.S. Patent Application Ser. No. (15311-2292) entitled PASSIVE RELEASE AVOIDANCE TECHNIQUE;

U.S. Patent Application Ser. No. (15311-2293) entitled COHERENT TRANSLATION LOOK-ASIDE BUFFER;

U.S. Patent Application Ser. No. (15311-2294) entitled DETERMINISTIC HARDWARE BEHAVIOR BETWEEN MULTIPLE ASYNCHRONOUS CLOCK DOMAINS THROUGH THE NOVEL USE OF A PLL; and

U.S. Patent Application Ser. No. (15311-2306) entitled VIRTUAL TIME OF YEAR CLOCK.

Field of the Invention

This invention relates to the transfer of data between different integrated circuits (IC's). It is of particular utility in the transfer of data between IC's on different circuit boards interconnected by cables of varying lengths. The invention uses a novel clock-forwarding arrangement to synchronize operations on the data-receiving units to those on the transmitting chips.

Background Information

The transfer of data between various units in a data-processing system is normally effected by a physical connection between an output latch on the transmitting unit and an

input latch on the receiving unit. This requires that the data be clocked into the input latch as it is received over the physical connection. At relatively low clock frequencies a system-wide clock can be used for this purpose. However, with high clock frequencies, corresponding with high data-transfer rates, clock skew, i.e. the difference in clock phase in different points in the system, presents a problem. Specifically, the clock edges at which the data is clocked into the input latches may not occur at the times the incoming data is received, resulting in errors in data reception.

To overcome this problem various clock-forwarding arrangements have been used, with transmitting units sending their clock signals to the receiving units along with the data. The clock signals arrive at the input latches of the latter units along with the data and the data is therefore clocked into the latches with greatly reduced clock-skew error.

Once received, the data must be moved from the input latch to other components that are to process the data in accordance with the function of the receiving unit. These components operate in synchronism with a local clock and the transfers from the input latch must therefore be effected in such manner as to accommodate the phase differences between the forwarded clock and the local clock. One can use a FIFO buffer for this purpose, the input latch being the input stage of the buffer. The buffer can thus be loaded in accordance with the forwarded clock and unloaded in accordance with the local clock. However to insure proper operation the buffer must be large enough to contain the largest burst of data that will be received by the receiving unit. This results in undue latency in each transfer, since incoming data must pass through the successive stages of the buffer before it is accessible to the receiving unit.

As connection lengths between the transmitting node and the receiving node change in a clock forwarded system, so does the phase relationship between the forwarded clock seen at the receiving node and the local clock at the receiving node. One can account for these phase differences by pre-calculating the expected phase differences and accounting for these differences in the receive logic by modifying when data is first

removed from the FIFO. This has the advantage of reducing latency, but each time the connection length is changed, calculations must be made and the operation of the receive logic must be modified (which is typically accomplished via register bits that are written by an external means) in order to account for the change in length. In cases where connections between the transmitting node and the receive node are of great length, process variations within a standard connection length used may result in skews too great to be able to correct. In this instance, larger FIFOs must be again utilized and latencies increase and bandwidths suffer.

SUMMARY OF THE INVENTION

The present invention generates a phase and edge aligned local clock signal in the data-receiving unit by deriving it from the forwarded clock signal from the transmitting unit.. Transfers from the input latch to other components in the receiving unit can be thus effected in step with the receipt of data in the input latch. Specifically, data can be transferred from the input latch after it has been loaded therein and before receipt of the next data transmission. For example, if the data is clocked into the input latch on positive-going edges of the clock signal, it can be transferred out of the input latch on negative going edges. This eliminates the latency incurred with the use of FIFO buffers, while insuring the validity of the data passed to other components in the receiving unit.

The invention is particularly applicable to double-data-rate transfers, in which a pair of input latches are loaded with data on alternate transitions of the forwarded clock signal. That is, one latch is loaded on positive-going edges and the second on negative-going edges. As described below a slight delay is imposed in the transfer of data from one of the latches to a third latch that receives the concatenated data of the two input latches.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention description below refers to the accompanying drawings which is a diagram of a data-receiving unit incorporating the invention.

DETAILED DESCRIPTION OF AN ILLUSTRATIVE EMBODIMENT

In drawing I have illustrated the use of the invention in transmitting data from a central processor unit (CPU) 10 and to a data unit 12. The units 10 and 12 are parts of a data processing system, which includes other units that need not be depicted for the purposes of this description. The unit 12 may be, for example, an I/O Bridge that connects a processor to industry standard busses such as PCI, PCI-X, AGP . It may reside on a separate circuit board from the CPU 10, in which case data transmissions from the CPU to the unit 12 pass over a cable 14. The cable 14 includes a set of data conductors 16 and clock conductors 17 and 18. The conductors 17 and 18 carry a clock signal; the versions on the two conductors being of opposite phase. The CPU 10 transmits data over the data conductors 16 in synchronism with the clock signal. Specifically, whenever a transition in a clock signal is transmitted from the CPU 10, corresponding data is transmitted over the conductors 16. The incoming signals pass through receivers 19.

The illustrated system provides for double data-rate transmissions. That is, the CPU 10 transmits data in synchronism with both the positive-going and negative-going transistors of the clock signal. However the invention is applicable also to systems in which the transmissions are synchronized with only the positive-or negative-going transitions.

For data reception from the CPU 10, the receiving unit 12 includes a pair of input latches 20 and 22 that receive the data transmitted over the cable 14, a pair of latches 24 and 26 that concatenate the data received by the latches 20 and 22, and a phase-lock loop PLL 28 that generates a local clock signal for the unit 12. The latches 20 and 22 have data input terminals 20d and 22d that receive the data transmitted over the cable conductor 16. The clock input terminals 20c and 22c receive delayed versions of the clock signal from delay elements 30 and 32. The elements 30 and 32 preferably provide a delay of

90° to issue to insure that the latches 20 and 22 are clocked after the data voltages have settled. A delay element 34 is interposed in the data input to compensate for delay of the clock signal cause by the load imposed by the inputs to which the latter signal is delivered.

The data output of the input latch 20 is applied directly to the data input terminal 24d of the later 24.

The data output of the input latch 22 is applied to the data input terminal 26d of the latch 26 by way of a delay element 38 whose function is described below.

The phase lock loop 28 receives as a reference input the forwarded clock signal CLK from the CPU 10. The other input of the PLL 28 is provided by the output of the PLL, delayed by a delay element 42. The electrical lengths of clock lines 44, 46 and 48 are equal to each other. The output of the PLL is a local clock signal for the various components of the receiving unit 12 other than the input latches 20 and 22. The delay element 42 replicates the delay between the PLL 28 and the components that receive the local clock signals. These components are thus clocked in synchronization and in phase with the forwarded clock signal as received at the input latches 20 and 22.

The latch 22 is triggered by the positive-going edges of the incoming clock signal CLK and the latch 20 is triggered by the negative-going edges of the same signal. Thus the latches 20 and 22 are loaded on alternate clock edges. The latches 24 and 26 are both loaded on the positive-going edges of the local clock.

The delay element 38 is inserted between the output of the input latch 22 and the data input terminal of the latch 26 to deal with the effects of clock jitter, i.e. short term variations in the phase of the local clock relative to that of the forwarded clock signal applied to the latches 22. Both of the latches 22 and 26 respond to positive-going CLK edges. If a positive edge of the local clock arrives at the clock input terminal 26 c slightly before the arrival of the positive edge of the forwarded clock signal at the terminal 22c, valid data from the input latch 22 will be transferred to the latch 2. However, if the local clock edge arrives at the terminal 26c subsequent to the arrival of the corresponding edge of the terminal 22c, the contents of the latch 22 may change before they

are be transferred to the latch 26. The delay unit 38 delays the arrival of the change in latch 22 contents at the data input terminal 26d so as to insure that even a slightly late clock edge at the terminal 26c will load the correct data into the latch 26.

There is no need for a corresponding delay in the data input of the latch 24, since it is clocked a half clock cycle before the next change in the contents of the input latch 20.

As an example of the delay provided by the delay unit 38, we have used a delay of 400 pico seconds with a clock frequency of 200 megahertz.

CLAIMS

1. A data receiving unit for receiving data transmissions in which data is transmitted in parallel over a plurality of conductors and a forwarded clock signal, synchronized with the data, is received over a further conductor, said unit comprising:

a. an input latch connected to receiving the data on said data conductors, said latch being clocked by alternate transitions of said forwarded clock check signal,

b. means for maintaining a delayed replica of said forwarded clock signal in synchronism with said forwarded clock signal, said delayed replica being a local clock signal for internal operations of said receiving unit,

c. a second latch connected to receive the contents of said input latch, said second latch being clocked by said local clock signal on transitions alternate to those on which said input latch is clocked.

2. A data receiving unit for receiving double-data-rate transmissions in which data is transmitted in parallel over a plurality of conductors and a forwarded clock signal, synchronized with the data, is received over a further conductor, said unit comprising:

a. first and second input latches connected to receive the data on said data conductors, said latch as being clocked by alternate transitions of said forwarded clock signal,

b. means for maintaining a delayed replica of said forwarded clock signal in synchronism with said forwarded clock signal, said delayed replica being a local clock signal for internal operations of said receiving unit,

c. the third and forth latches connected to receive the contents of said first and second input latches, respectively, said third and forth latches being clocked the same transitions of said local clock signal.

3. The receiving unit defined in claim 2 in which said first and third latches are clocked by corresponding clock edges and further including a delay element disposed in the data path from said first latch to said third latch, thereby to prevent jitter in the relative phase of the clock signals applied to said first and third latches from causing errors in the transfer of data from said first latch to said third latch.

4. The data receiving unit defined in claim 3 in which said synchronism maintaining means synchronizes said delayed replica with the forwarded clock signal as received at said first latch.

5. The receiving unit defined in claim 4 in which said local clock signal is delayed relative to the forwarded clock signal by an interval that is substantially equal to the time required for the local clock signal to reach components in said receiving unit clocked by that signal.

ABSTRACT OF THE DISCLOSURE

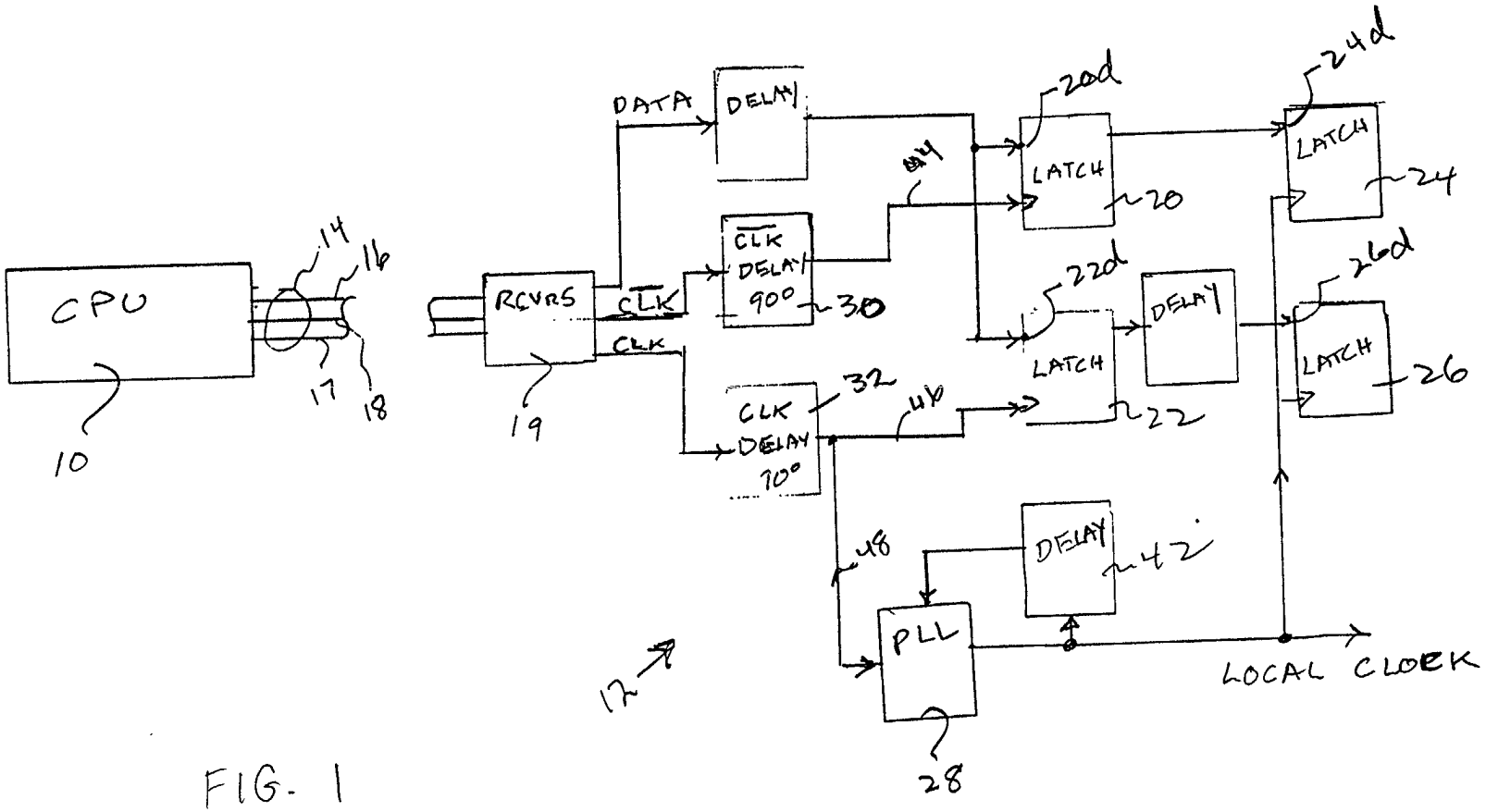

FIG. 1